

Work Paper PGECOLTGxxx LED Panel Fixtures and Retrofit Kits Revision # 0

Pacific Gas & Electric Company
Customer Energy Solutions

LED Panel Fixtures and Retrofit Kits

Measure Codes LDxx1 – LDxx3

At-a-Glance Summary

Applicable Measure Codes:	LDxx1, LDxx2, LDxx3
Measure Description:	LED Panel Fixtures and Retrofit Kits
Energy Impact Common Units:	Kilolumen of LED initial light output
Base Case Description:	Linear fluorescent recessed fixture or kit in 2x4, 2x2 or 1x4 size, with lamp and ballast meeting federal standard. Source: PG&E Calculations.
Base Case Energy Consumption:	Various. Refer to .xlsx file attached Source: PG&E Calculations.
Measure Energy Consumption:	Various. Refer to .xlsx file attached Source: PG&E Calculations.
Energy Savings (Base Case – Measure):	Various. Refer to .xlsx file attached Source: PG&E Calculations.
Costs Common Units:	\$ per kilolumen.
Base Case Equipment Cost (\$/fixture):	Various. Refer to .xlsx file attached. Source: Distributor Quotations and Weblinks
Measure Equipment Cost (\$/fixture):	Various. Refer to .xlsx file attached Source: Manufacturer Rep & Distributor Quotations and Weblinks
Gross Measure Cost (\$/fixture)	Various. Refer to .xlsx file attached Source: Manufacturer Rep & Distributor Quotations and Weblinks
Measure Incremental Cost (\$/fixture):	Various. Refer to .xlsx file attached Source: PG&E Calculations
Effective Useful Life (years):	Various. Refer to .xlsx file attached Source: DEER maximum
Program Type:	ROB/NC.
Net-to-Gross Ratios:	NTG= 0.70, All-Default<=2yrs Source: DEER 2013 v1.0
Important Comments:	

Work Paper Approvals

The following Manager(s) approved this workpaper through the PG&E Electronic Data Routing System under Routing Requisition #

Grant Brohard

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Document Revision History

Revision #	Date	Section by Section Description of Revisions	Author (Company)
Revision 0	2/25/2015	PGECOLTGxxx R0 Panel Fixtures and Retrofit Kits.doc Original Workpaper	Author: Greg Barker (Energy Solutions) Reviewer: Alina Zohrabian (PG&E)

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Section 1. General Measure & Baseline Data

1.1 Product Measure Description & Background

Catalog Description

Light Emitting Diode (LED) Panel Fixtures and Retrofit Kits

Requirements:

- Must be a one for one replacement for a Linear Fluorescent Fixture with T8 or T5 lamps
- Must be on the Design Lights Consortium (DLC) qualified product list as Ambient Lighting of Interior Commercial Spaces in one of the following sizes: 2x4, 2x2, 1x4
- DLC-listed initial light output must be ≥ 2200 lm and ≤ 6500 lm
- Tubular LED lamps (T-LEDs) do not qualify
- Fixtures and kits that do not have lenses between the LED package and the viewer do not qualify.
- Self-ballasted or screw-based lamps do not qualify.
- 5-year warranty minimum
- Must meet the minimum efficacy requirements listed in Table 1.

Table 1 - LED Panel Fixtures & Retrofit Kits Base and Measure Wattages

Measure Code	Measure Description	Base Case system wattage per kilolumen (COM)	LED Watts per kilolumen	Delta Watts per kilolumen (COM)
LDxx1	New DLC-listed LED recessed fixture or kit rated greater than or equal to 85 LPW and less than 95 LPW	15.3	11.8	3.5
LDxx2	New DLC-listed LED recessed fixture or kit rated greater than or equal to 95 LPW and less than 105 LPW	15.3	10.5	4.8
LDxx3	New DLC-listed LED recessed fixture or kit rated greater than or equal to 105 LPW	15.3	9.5	5.8

Program Restrictions and Guidelines

This work paper details the replacement of linear fluorescent fixtures with LED Panel Fixtures & Retrofit Kits. The delivery method is Downstream Programs for commercial customers.

The LED fixture or retrofit kit must replace linear fluorescent recessed fixture on a 1-for-1 basis.

DLC requirements for Retrofit Kits and Luminaires for Ambient Lighting of Interior Commercial Spaces include:

- 5-year warranty
- 50,000 hour L70 Lumen Maintenance
- ≥ 80 Color Rendering Index (CRI)

- ≥ 85 lumens / Watt
- ≤ 5000 Kelvin Correlated Color Temperature (CCT)
- Spacing Criteria from 1.0 to 2.0 in both the 0-180° and 90-270° directions
- $\geq 75\%$ of Lumen Output in the 0-60° zone

Downstream Market Channel	
<ul style="list-style-type: none"> • Must be on Design Lights Consortium Qualified Products List, in one of 6 categories: <ul style="list-style-type: none"> ○ 2x2 Luminaires for Ambient Lighting of Interior Commercial Spaces ○ Retrofit Kits for 2x2 Luminaires for Ambient Lighting of Interior Commercial Spaces ○ 1x4 Luminaires for Ambient Lighting of Interior Commercial Spaces ○ Retrofit Kits for 1x4 Luminaires for Ambient Lighting of Interior Commercial Spaces ○ 2x4 Luminaires for Ambient Lighting of Interior Commercial Spaces ○ Retrofit Kits for 2x4 Luminaires for Ambient Lighting of Interior Commercial Spaces 	

Terms and Conditions:

The customer must be a non-residential PG&E electric customer.

Market Applicability:

The customer must be a non-residential PG&E electric customer.

Type of Transaction:

The applicable types of transactions include Replace on Burnout. The rebate incentivizes the choice of energy efficient equipment over the base case equipment, which is a Linear Fluorescent T8 fixture or retrofit kit.

The Hard to Reach designation for NTG application must meet the following criteria from the Energy Efficiency Policy Manual.

Residential Hard-to-Reach: Those customers who do not have easy access to program information or generally do not participate in energy efficiency programs due to a language, income, housing type, geographic, or home ownership (split incentives) barrier. These barriers are defined as:

Language – Primary language spoken is other than English, and/or

Income – Those customers who fall into the moderate income level (income levels less than 400% of the federal poverty guidelines and/or

Housing Type – Multi-family and Mobile Home Tenants, and/or

Geographic – Businesses in areas other than the San Francisco Bay Area, San Diego area, Greater Los Angeles Area (Los Angeles, Orange, San Bernardino, Riverside and Ventura counties) or Sacramento, and/or

Home Ownership – Renters

Non Residential Hard-to-Reach:

Everything in the Res section plus-

Hard to reach business customers also include factors such as business size and lease (split incentive) barriers.

1.2 Product Technical Description

Light emitting diode (LED) sources have improved over the past decade making them an efficient and reliable lighting technology. Many LED products have successfully replaced other lighting sources and made their way into the market through continuous improvement and compete with more established sources across many applications.

Recessed fixtures, sometimes known as troffers, have traditionally used linear fluorescent light sources: T8 lamps predominate currently, with small T5 market share and a diminishing T12 presence in non-residential building stock. Similar fixture shapes are in use for much less common surface mountings in non-residential buildings, for spaces where recessed ceiling space is unavailable but ease of maintenance dictates a common lamp type. 4 foot lamps predominate, with 2 foot or U-bent 4 foot lamps also common.

Improvements in LED technology, particularly improving efficacies able to compete with and exceed the best T8 lamp-and-ballast systems producing over 95 lumens per Watt, have made LED panel fixtures feasible. These are fixtures with output of at least 1,500 lumens. Currently DLC requires LED panels and kits achieve output of at least 1,500 lumens. Panels eligible for these measure codes shall have initial light output rated between 2200 lumens and 6500 lumens.

LED fixtures under this workpaper are assigned a measure code according to efficacy. The energy impact common unit is the kilolumen of initial rated light output for the LED fixture, according to the DLC listing.

This workpaper describes the energy savings associated with their replacement of linear fluorescent fixtures.

1.3 Measure Application Type

The DEER Measure Cost Data Users Guide found on www.deeresources.com under *DEER2011 Database Format* hyperlink, DEER2011 for 13-14, spreadsheet *SPTdata_format-V0.97.xls*, defines the terms as follows:

Table 2 Measure Application Type¹

Identifies the measure application type in the Measure Implementation table in DEER2011.

Code	Description	Comment
ER	Early retirement	measure applied while existing equipment still viable, or retrofit of existing equipment
ROB	Replace on Burnout	measure applied when existing equipment fails or maintenance requires replacement
NC	New Construction	measure applied during construction design phase as an alternative to a code-compliant standard design

All the measures within this workpaper are ROB.

1.4 Product Base Case and Measure Case Data

Eligible measure case fixtures for these measure codes are LED panels with initial light output between 2200 and 6500 lumens. Appropriate base case fixtures are linear fluorescent fixtures that will have equivalent maintained illuminance to those LEDs at the end of effective useful life. The Effective Useful Life is 50,000 hours based on the DLC-minimum rated hours, except where this value exceeds the DEER run hours for a given building type over the 20 year DEER measure maximum life, in which case the effective useful life is 20 years. Given the great number of variations on linear fluorescent lamp and ballast configurations and resultant light outputs, and that groupings made by wattage as in previous

custom do not accurately reflect illumination between LED and linear fluorescent fixtures, the efficacy and wattages of both base case and measure case fixtures are not grouped by lamp and ballast configuration but characterized in units of kilolumens of initial LED light output with energy impacts scaling with these kilolumen units. Cost, wattage and savings are all in units of kilolumen.

1.4.1 DEER Base Case and Measure Case Information

The Database for Energy Efficient Resources (DEER) 2014 does not address LED savings for panel fixtures and kits.

Net-to-Gross Assumption:

The NTGR value is from DEER 2013 v1.0². Table 1 below summarizes all applicable Net-to-Gross ratios for programs that may be used by this measure.

Table 3 - Net-to-Gross Ratios

NTGR_ID	Description	NTG
All-Default<=2yrs	All other EEM with no evaluated NTGR; new technology in program for 2 or fewer years	0.70

Effective Useful Life / Remaining Useful Life

The rated life for these products is assumed to be 50,000 hours, the minimum DLC specification. Rated life for DLC-listed products varies between 50,000 hours and 500,000 hours. Since the EUL is dependent on the DEER hours of operation, the EUL expressed in years varies by building type. EUL is also limited by the established DEER measure maximum of 20 years.

The EUL is based on 50,000 hours rated fixture life divided by average annual hours of operation for each building type, with a maximum of 20 years:

$$\text{EUL} = (\text{DLC-Minimum Fixture Life (hours)}) / (\text{Average Operating Hours Per Year})$$

1.4.2 Codes & Standards Requirements Base Case and Measure Information

Title 20: These measures do not fall under Title 20 of the California Energy Regulations.

Title 24: These measures do not fall under Title 24 of the California Energy Regulations. The Lighting Power Densities of both measure and base case are capped by Title 24, but both measure and base cases are configured so as to be compliant with Title 24, with the measure capturing savings above Title 24 minimums.

Federal Standards: These measure case fixtures do not fall under Federal DOE or EPA Energy Regulations. Both General Service Fluorescent lamps and ballasts are energy-using components of linear fluorescent fixtures and are regulated by Federal Standards.

1. 4-foot medium bi-pin lamps ≤4500K are required to meet 89 LPW (2,848 lm per 32 Watt lamp)³
2. Ballasts for 4-foot medium bi-pin lamps are required by EPCA's 2011 amendment to have a luminous efficacy no less than $0.993/(1 + 0.27 \times \text{total lamp arc power} - 0.25)$ ⁴

1.4.3 EM&V, Market Potential, and Other Studies – Base Case and Measure Case Information

1.4.3.1 CALiPER Application Summary Report 13:⁵

A few of the conclusions that CALiPER reported in its most recent application summary report on LED Panels (#13 from 2011) from tests of 6 LED 2x2 troffer fixtures:

- LED products tested were more efficacious and produced more light output than some, but not all, of the fluorescent benchmark products
- 5 of 6 products performed as claimed in product literature, and one significantly underperformed

5 LED troffers had been tested in a few previous CALiPER reports in 2009 or earlier, with 4 of the 5 having efficacies similar to fluorescent benchmarks, and with typically lower spacing criteria.

1.4.4 Assumptions and Calculations from other sources—Base and Measure Cases

The fixture performance in the applicable categories of the DLC list—LED Luminaires and Retrofit Kits for Ambient Lighting of Interior Commercial Spaces—was analyzed to justify the light output equivalency assumptions. The 6,840 fixtures in these categories were analyzed for luminaire efficacy.

Delta Wattage Assumption (ΔW)

The base case linear fluorescent fixtures were modeled across the DLC light output range according to the most common fixture type in a configuration meeting appropriate Federal lamp standards, Federal ballast standards, and California Title 24 (T24) interior commercial lumen power density (LPD) requirements. Rather than assume a single base case lamp-and-ballast-and-fixture combination as a base case, the efficacy of a standards-compliant base case fixture in terms of lumens per Watt (LPW) is used to calculate savings.

The code-compliant base case fixture model used is from the 2011 Codes and Standards Enhancement (CASE) Report for Indoor Lighting Controls.⁶ This report developed the most thorough commercial interior lighting model available in California standards proceedings. The model used by CASE author offers a combination of interior spaces: large open-plan areas as found in many offices, as well as small spaces typical of private offices or meeting rooms. The panel fixtures modeled are 2x4 3-lamp T8 parabolic fixtures, matching a typical parabolic luminaire with 74.7% fixture efficacy.⁷

The model was updated to 2013-T24 LPD specifications, which reduce LPDs for Offices via the Complete Building Method from 0.9 W/sf to 0.8 W/sf.⁸ The model was changed to reflect Federal fluorescent lamp minimum standards with a 2950-lumen lamp, but the ballast was unchanged as it reflected a premium electronic ballast listed by the Consortium for Energy Efficiency's HPT8 standard and the National Electrical Manufacturers Association's NEMA Premium listing. The CASE Report model's assumption for Light Loss of 9.7% was used. The model suggests that illumination from recessed fluorescent fixtures compliant with current code can be obtained at maintained fixture efficacy of 58.8 LPW. This figure is higher, accounting for 9.7% lumen depreciation, than the 5 fluorescent benchmark troffer fixtures tested in CALiPER Rounds 9 and 13 (all of which were 2x2 fixtures).⁹

The DOE Solid-State Lighting CALiPER Reports have examined 12 LED panel fixtures combined in application summary reports 1, 5, 7, 9 and 13, but none of these tests are dated more recently than September of 2011, making them of limited relevance for a workpaper in 2015 given LED improvements. Given their age, CALiPER reports were not used for determining equivalency.

Initial LED lumen efficacy assumptions are set by the measure code minimum requirements, starting with 85 LPW for the lowest-efficacy measure code corresponding with DLC's minimum efficacy. Calculating the wattage corresponding to this efficacy for a unit of one kilolumen can be accomplished by dividing 1000 lumens by 85 lumens per watt, resulting in 11.8 Watts per kilolumen for the measure case.

Maintained lumen output equivalency was based on the full list of DLC products and on LED lumen maintenance data from the Lighting Facts database. All 156 Lighting Facts fixtures with lumen

maintenance information were considered as a full dataset, as well as the subset of 20 fixtures that were both DLC-listed and available with lumen maintenance values for the 25,000-hour mark, the mid-point of the 50,000 DLC specification minimum. The full dataset is provided in the calculations file for this workpaper. Analysis of both the full set and subset, in accordance with the LED lumen output extrapolation formula published in Federal rulemaking,¹⁰ suggests LED fixture lumen maintenance at EUL of 86.8% for the blended Commercial building type with 3077.9 DEER Measure hours per year for 20 years, based on the following calculation:

$$\begin{aligned}
 \text{Com EUL hours per DEER} &= \text{DEER Annual Measure HOU}_{\text{std}} \times \text{EUL fixture maximum} \\
 &= 3077.9 \text{ hours/year} \times 20 \text{ year maximum EUL} \\
 &= 61,558.0 \text{ hours is greater than 50,000} \\
 &50,000 \text{ hour EUL is used for Com building type}
 \end{aligned}$$

LED lumen maintenance varies by building type due to differing DEER run hours. Motel annual run hours of 1500 result in 30,000 run hours over 20 year EUL, and thus 91.8% lumen maintenance. DEER annual run hours in half of the DEER building types, including the Large Retail, Restaurant and Grocery, over 20 years will exceed 50,000 hours, so the 50,000 DLC-minimum rated life fixture is used, along with an 86.8% lumen maintenance figure. The calculation, based on the Federal extrapolation formula, is taken across all 20 DLC-listed fixtures with 25,000-hour Lighting Facts data available, as follows:

$$\begin{aligned}
 \text{Lumen Maintenance at Com EUL} &= \\
 &e^{\text{ComEUL hours} \times \ln \text{Lumen Maintenance \% @ 25,000 hours} \div 25,000 \text{ hours}} \\
 &= e^{50,000 \times \ln 93.121 \div 25,000} \\
 &= 86.8\% \text{ lumen maintenance}
 \end{aligned}$$

Section 2. Calculation Methods

This workpaper does not group base and measure case fixtures by wattages. The base case and measure wattages are determined by the methods described in section 1.4.4.

Table 4 - LED Panel Fixtures & Retrofit Kits Base and Measure Wattages

Base Case	Base Case Wattage	Measure Case Wattage	Delta Wattage
Linear Fluorescent panel with maintained light output equal to LED panel of one kilolumen output and 85 to 95 LPW	14.8 – 15.6	11.8	3.0 – 3.8
Linear Fluorescent panel with maintained light output equal to LED panel of one kilolumen output and 95 to 105 LPW	14.8 – 15.6	10.5	4.3 – 5.1
Linear Fluorescent panel with maintained light output equal to LED panel of one kilolumen output and greater than 105 LPW	14.8 – 15.6	9.5	5.3 – 6.1
Base case wattage varies by building type			

2.1 Electric Energy Savings Estimation Methodologies

The lighting wattage difference (Watts per unit) is the difference between the electric demand of the base case unit and the electric demand of the measure case unit. The hours of operation and interactive effects are from DEER 2014.

ΔWatts/kilolumen: The demand difference (watts per kilolumen) is simply the difference between the electric demand of a kilolumen unit of the base case fixture and the electric demand of a kilolumen unit of the measure case fixture.

$$\Delta\text{Watts/kilolumen} = \text{Base Case Watts/kilolumen} - \text{Measure Case Watts/kilolumen}$$

Example:

$$\Delta\text{Watts/kilolumen} = 14.8 \text{ W} - 11.8 \text{ W} = 3.0 \Delta\text{Watts/kilolumen}$$

Annual Electric Savings:

$$\text{Annual Energy Savings [kWh/kilolumen]} = (\Delta\text{Watts/kilolumen}) \times (\text{Annual Hours of Operation}) \times (\text{Energy Interactive Effects}) / (1,000 \text{ Watts} / \text{kW})$$

2.2. Demand Reduction Estimation Methodologies

This measure includes HVAC interactive effects savings. This measure is not an Early Retirement measure.

ΔWatts/kilolumen: The demand difference (watts per kilolumen) is simply the difference between the electric demand of a kilolumen unit of the base fixture and the electric demand of a kilolumen unit of the energy efficient fixture.

$$\Delta\text{Watts/kilolumen} = \text{Base Watts/kilolumen} - \text{Energy Efficient Watts/kilolumen}$$

Where:

Base Case Watts/Kilolumen represents code/industry standard base unit demand.

Demand Reduction:

$$\text{Demand Reduction [kW/kilolumen]} = (\Delta\text{Watts/kilolumen}) \times (\text{Lighting Coincident Demand}) \times (\text{Demand Interactive Effects}) / (1,000 \text{ Watts/kW})$$

2.3. Gas Energy Savings Estimation Methodologies

Gas estimates are entirely based on the estimated increased gas use through calculated interactive effects. This measure includes HVAC interactive effects impacts. This measure is not an Early Retirement measure.

ΔWatts/kilolumen: The demand difference (watts per kilolumen) is simply the difference between the electric demand of a kilolumen unit of the base fixture and the electric demand of a kilolumen unit of the energy efficient fixture.

$$\Delta\text{Watts/kilolumen} = \text{Base Watts/kilolumen} - \text{Energy Efficient Watts/kilolumen}$$

Annual Gas Savings:

$$\text{Annual Gas Savings } [\Delta\text{Therms/kilolumen}] = (\Delta\text{Watts/kilolumen}) \times (\text{Annual Hours of Operation}) \times (\text{Gas Interactive Effects}) / 1,000 \text{ Watts/kW}$$

Section 3. Load Shapes

Load Shapes are an important part of the life-cycle cost analysis of any energy efficiency program portfolio. The net benefits associated with a measure are based on the amount of energy saved and the avoided cost per unit of energy saved. For electricity, the avoided cost varies hourly over an entire year.

Thus, the net benefits calculation for a measure requires both the total annual energy savings (kWh) of the measure and the distribution of that savings over the year. The distribution of savings over the year is represented by the measure's load shape. The measure's load shape indicates what fraction of annual energy savings occurs in each time period of the year. An hourly load shape indicates what fraction of annual savings occurs for each hour of the year. A Time-of-Use (TOU) load shape indicates what fraction occurs within five or six broad time-of-use periods, typically defined by a specific utility rate tariff. Formally, a load shape is a set of fractions summing to unity, one fraction for each hour or for each TOU period. Multiplying the measure load shape with the hourly avoided cost stream determines the average avoided cost per kWh for use in the life cycle cost analysis that determines a measure's Total Resource Cost (TRC) benefit.

3.1 Base Case Load Shapes

The closest load shape chosen for this measure is the "DEER:Indoor_Non-CFL_Ltg" load shape.

3.2 Measure Load Shapes

The measure load shape for this measure is determined based on the applicable non-residential market sector and the lighting end-use.

The closest load shape chosen for this measure is the DEER:Indoor_Non-CFL_Ltg load shape. See the KEMA report [31] for a more thorough discussion regarding the load shapes for this measure.

Section 4. Base Case & Measure Costs

DEER 2014 does not have measure cost data for LED fixtures.

4.1 Base Case Costs

It is assumed the labor cost of replacing the measure case fixture would be the same as the base case fixture. The base case and measure case costs include just equipment costs. The base case costs are taken from distributor catalogs and websites and confirmed with manufacturer representatives where possible.

Table 5 – LED Panel Fixtures & Retrofit Kits Base Case Cost Table

Measure Description	Base Case Equipment Cost
All LED Panel Measures	\$ 15.58

4.2 Measure Costs

The measure equipment costs were developed from California distributor catalogs and websites and confirmed with manufacturer representatives where possible.

Table 6 - LED Panel Fixtures & Retrofit Kits Measure Cost Table

Measure Description	Measure Equipment Cost
New DLC-listed LED recessed fixture or kit rated greater than or equal to 85 LPW and less than 95 LPW	\$41.79
New DLC-listed LED recessed fixture or kit rated greater than or equal to 95 LPW and less than 105 LPW	\$43.83
New DLC-listed LED recessed fixture or kit rated greater than or equal to 105 LPW	\$49.44

4.3 Incremental & Full Measure Costs

Measure Application Type	Gross Measure Cost (RUL Period/First Baseline)	Gross Measure Cost (EUL-RUL Period/Second Baseline)	Incremental Measure Cost
ER	Measure Equipment Cost + Measure Labor Cost	(-1)x(Base Equipment Cost + Base Labor Cost)	Measure Equipment Cost – Base Case Equipment Cost
ROB	Measure Equipment Cost – Base Case Equipment Cost	N/A	Measure Equipment Cost – Base Case Equipment Cost
NC	Measure Equipment Cost – Base Case Equipment Cost	N/A	Measure Equipment Cost – Base Case Equipment Cost

4.3.1 Full Measure Cost

The Full Measure Cost is applicable to Direct Install programs.
 FMC = Measure Equipment Cost + Measure Labor Cost

Table 7 - LED Panel Fixtures & Retrofit Kits Full Measure Cost

Measure Description	Measure Equipment Cost	Measure Labor Cost ¹¹	Full Measure Cost
New DLC-listed LED recessed fixture or kit rated greater than or equal to 85 LPW and less than 95 LPW	\$41.79	\$18.01	\$59.80
New DLC-listed LED recessed fixture or kit rated greater than or equal to 95 LPW and less than 105 LPW	\$43.83	\$18.01	\$61.84
New DLC-listed LED recessed fixture or kit rated greater than or equal to 105 LPW	\$49.44	\$18.01	\$67.45

4.3.2 Incremental Measure Costs

The labor costs for measure and base cases are equivalent.
 Incremental cost (INCR) = Measure Cost – Base Case Cost

Table 8 - LED Panel Fixtures & Retrofit Kits Incremental Cost

Measure Description	Incremental Measure Cost
New DLC-listed LED recessed fixture or kit rated greater than or equal to 85 LPW and less than 95 LPW	\$ 26.21
New DLC-listed LED recessed fixture or kit rated greater than or equal to 95 LPW and less than 105 LPW	\$ 28.25
New DLC-listed LED recessed fixture or kit rated greater than or equal to 105 LPW	\$ 33.86

References:

¹ The DEER Measure Cost Data Users Guide found on www.deeresources.com under *DEER2011 Database Format* hyperlink, DEER2011 for 13-14, spreadsheet *SPTdata_format-V0.97.xls*.

² DEER2013 v1.0, see calculations workbook, NTGR worksheet

³ Code of Federal Regulations [10 CFR 430.32\(n\)](http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/70) ; accessed at http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/70

⁴ Fed Register 2011-28451.pdf ; accessed at <http://www.gpo.gov/fdsys/pkg/FR-2011-11-14/pdf/2011-28451.pdf>

⁵ CALiPER Summary Report Round 13. DOE. October 2011.

⁶ CASE_Nonres_Indoor_Lighting_Controls.pdf; accessed at http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/2011-04-04_workshop/review/Nonres_Indoor_Lighting_Controls.pdf

⁷ Cooper_2P2GAX332_3L_T8_18C_spec-sheet.pdf; accessed at http://www.cooperindustries.com/content/dam/public/lighting/products/documents/metalux/spec_sheets/090386_2P2GAX332_3L_T8_18C.pdf

⁸ CEC-Title24-2013.pdf, p. 205 (header indicating p. 190); accessed at <http://www.energy.ca.gov/2012publications/CEC-400-2012-004/CEC-400-2012-004-CMF-REV2.pdf>

⁹ CALiPER Summary Report Round 13, chart p. 21. DOE. October 2011.

¹⁰ Fed Register 2014-12127.pdf p. 17; accessed at <http://www.gpo.gov/fdsys/pkg/FR-2014-06-03/pdf/2014-12127.pdf>

¹¹ Measure Labor Cost is product of Installation time and Labor Rate. Labor rate of \$65 per hour taken from CALiPER Report 21.3, May 2014, page 9; accessed at http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/caliper_21-3_t8.pdf. Installation time of 65 minutes (average of 3rd and 4th LED kits completed by a commercial electrician) taken from CALiPER Exploratory Study: Recessed Troffer Lighting, March 2013, page 25; accessed at http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/caliper_recessed-troffer_2013.pdf